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Damage Initiation and Propagation in Metal Laminates

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The metal laminates proposed here for use in aircraft structures consist of aluminum interlayers between silicon carbide particle reinforced aluminum alloy plates. The properties of the laminates are to be tailored for applications in jet engine fan containment and in various wing and auxiliary support structures. One important mechanical property of the metal laminate is fracture toughness.

This composite metal structure is designed to have enhanced ductile fracture properties as a result of the plastic formability of the aluminum layers and increased strength and stiffness due to the layers of the metal matrix composite (MMC).

The enhanced fracture properties of the metal laminates are measured by fracture toughness specimens of several designs. Of particular interest is the optimum thickness of the ductile interlayer to optimize the fracture properties, but have the least effect on the strength and the stiffness. Specimen designs have been chosen which should allow measured properties of the specimen deformation and failure to be translated into predictions on component strength in actual aerospace applications.

One mode of the "extrinsic" fracture toughness produced in metal laminate structures, and evidenced in specimen failure, is extensive delamination between the ductile interlayer and the MMC plates.

The total area of delamination is increased by the tendency of metal laminates to have damage initiate at the lobes of contours of effective plastic strain which are significantly off-axis from the plane of Mode I or tensile mode opening crack growth. This off-axis damage increases the delaminated area and is a factor in forcing the crack to reinitiate at a new location in the next MMC plate.

Experimental evidence for this phenomena is presented, along with finite element calculations which quantify and explain enhanced fracture values. The progressive damage is modeled using tie-break slidelines with critical strains to failure chosen with the help of elastic-plastic fracture mechanics calculations.

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